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# Hard x-ray imaging and spectroscopy of long pulse NIF hohlraums

J. W. McDonald, R. L. Kauffman, L. J. Suter, J. R. Celeste, M. B. Schneider, J. P. Holder, J. Foster, E. Dewald, O. L. Landen

October 20, 2005

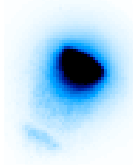
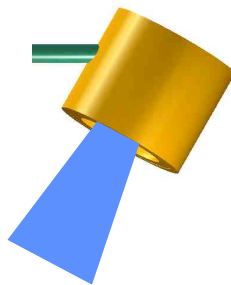
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Denver, CO, United States  
October 24, 2005 through October 28, 2005

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# Hard x-ray imaging and spectroscopy of long pulse NIF hohlraums



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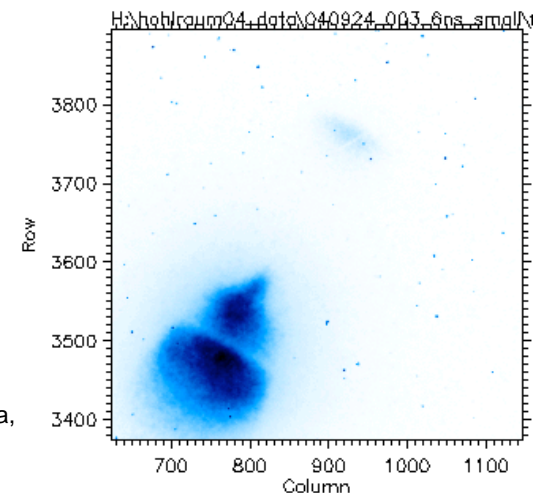
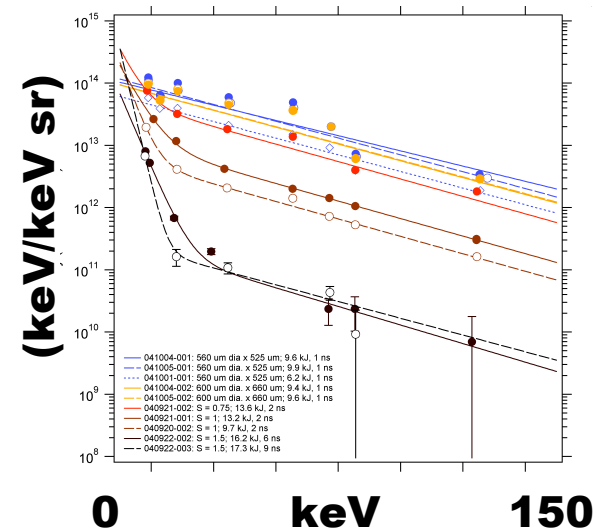
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Department of Plasma Physics

Denver, CO

October 24-28, 2006

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# Summary



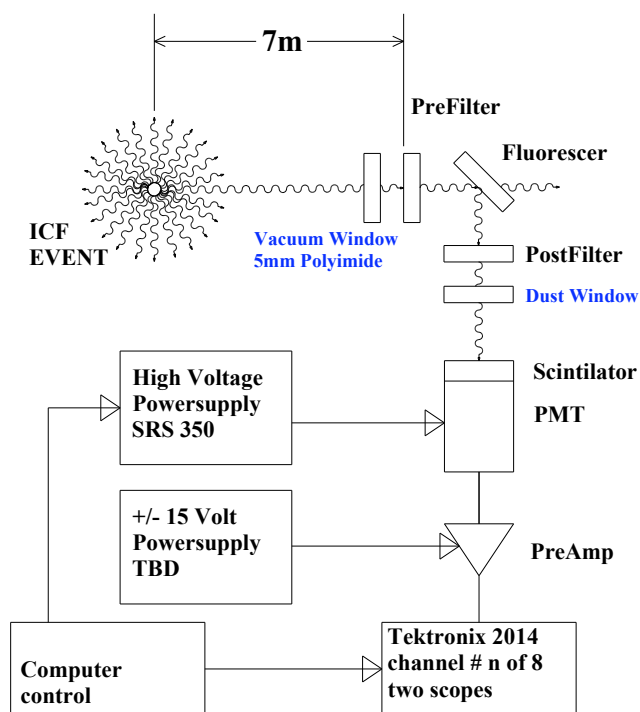
The National Ignition Facility

- Results from the hard x-ray Instruments fielded at NIF in recent shot campaign are discussed
  - Filter Fluorescer Experiment (FFLEX)
  - 10 keV x-ray Imager (HXRI)
- Data in the form of Hard x-ray spectra and images were collected from these instruments
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- RESULTS
  - FFLEX
    - $T_{\text{hot}} \sim 30$  keV
    - $F_{\text{hot}}$  scales with intensity and plasma fill model
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    - Migration of plasma from back wall to LEH seen as hohlraum fills

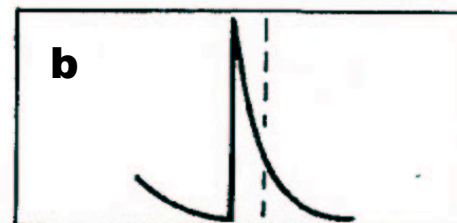


# What is FFLEX ?

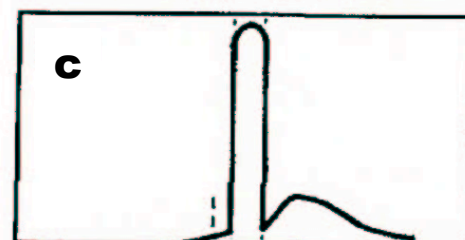
- An early Filter-Fluorescer Experiment has been added to NIF
- An absolutely calibrated, time integrated, x-ray spectrometer for energy range 20 to 200 keV
- Eight channels
  - 5 to 100 keV wide



**Pre-filter**



**Fluorescer**



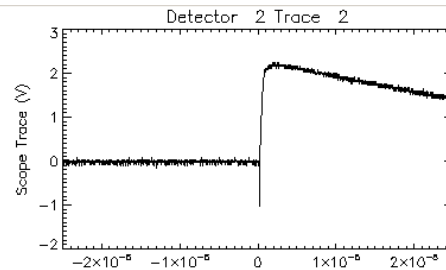
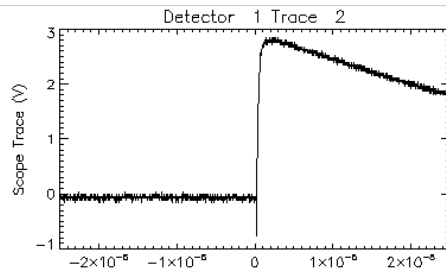
**Response a x b**

$E_k$   $E_f$   $E_p$  keV (log scale)

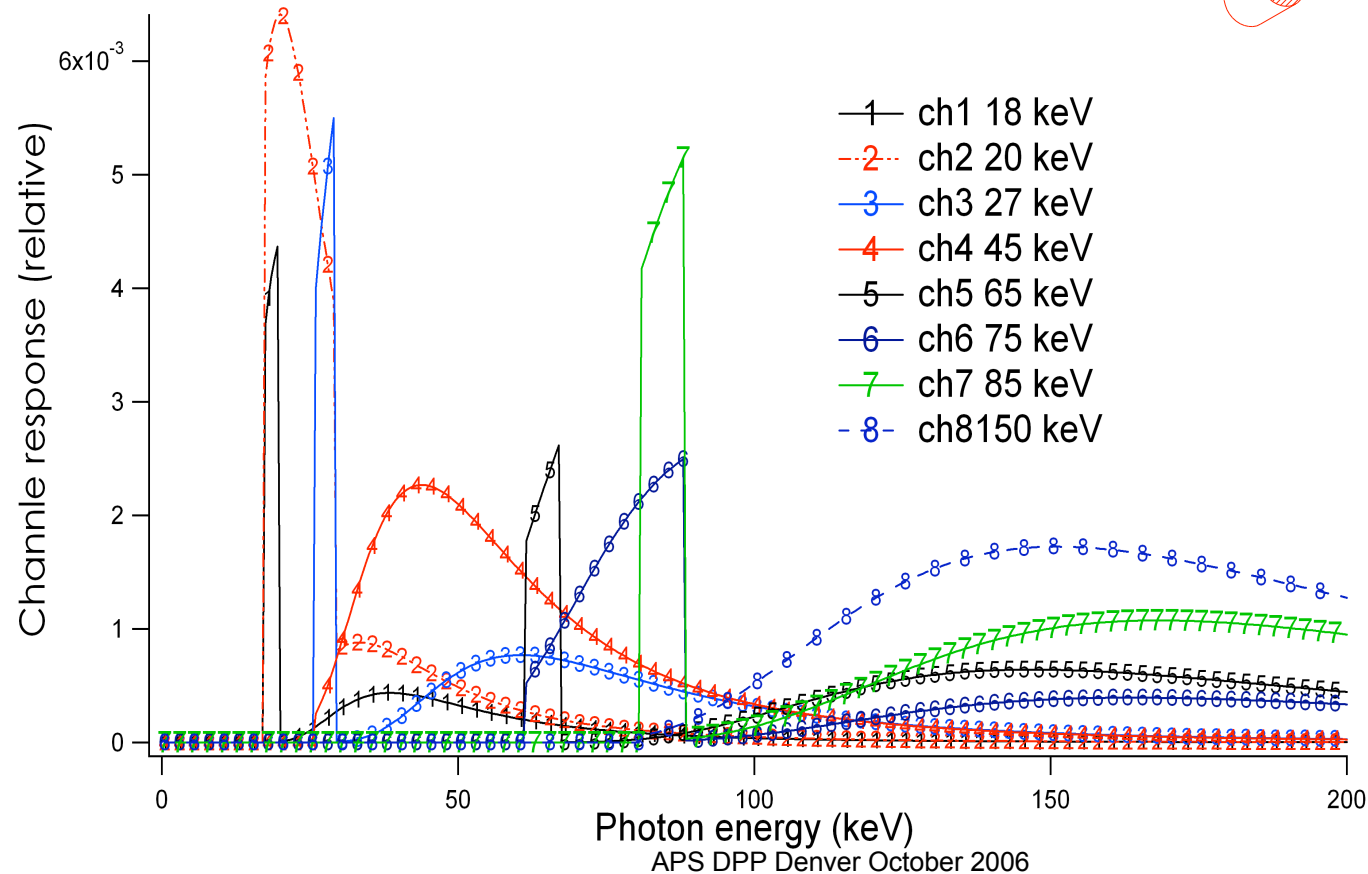
# FFLEX measures time-integrated hard x-rays from hot electron bremsstrahlung in hohlraums



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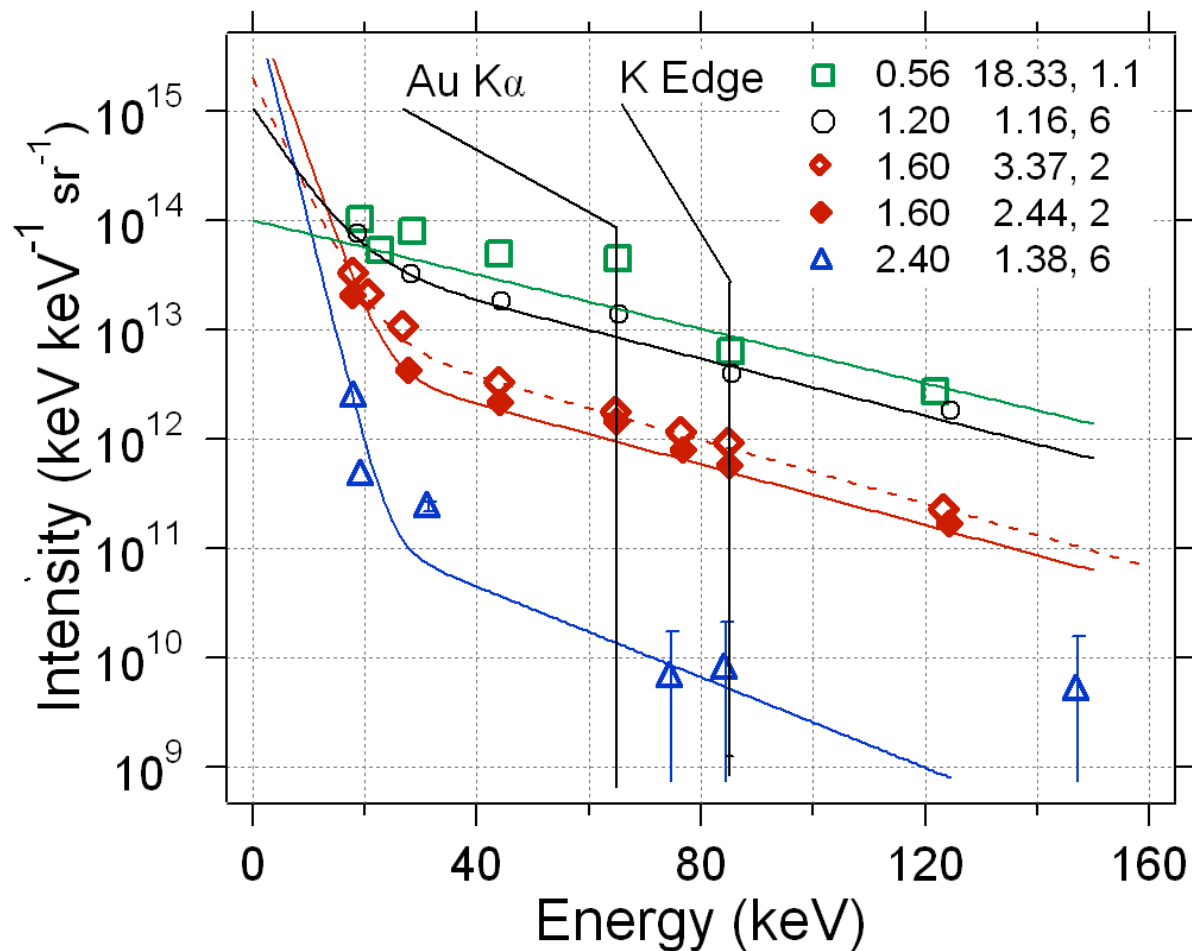


Scale 1  
IET  
View from  
FFLEX 90/110

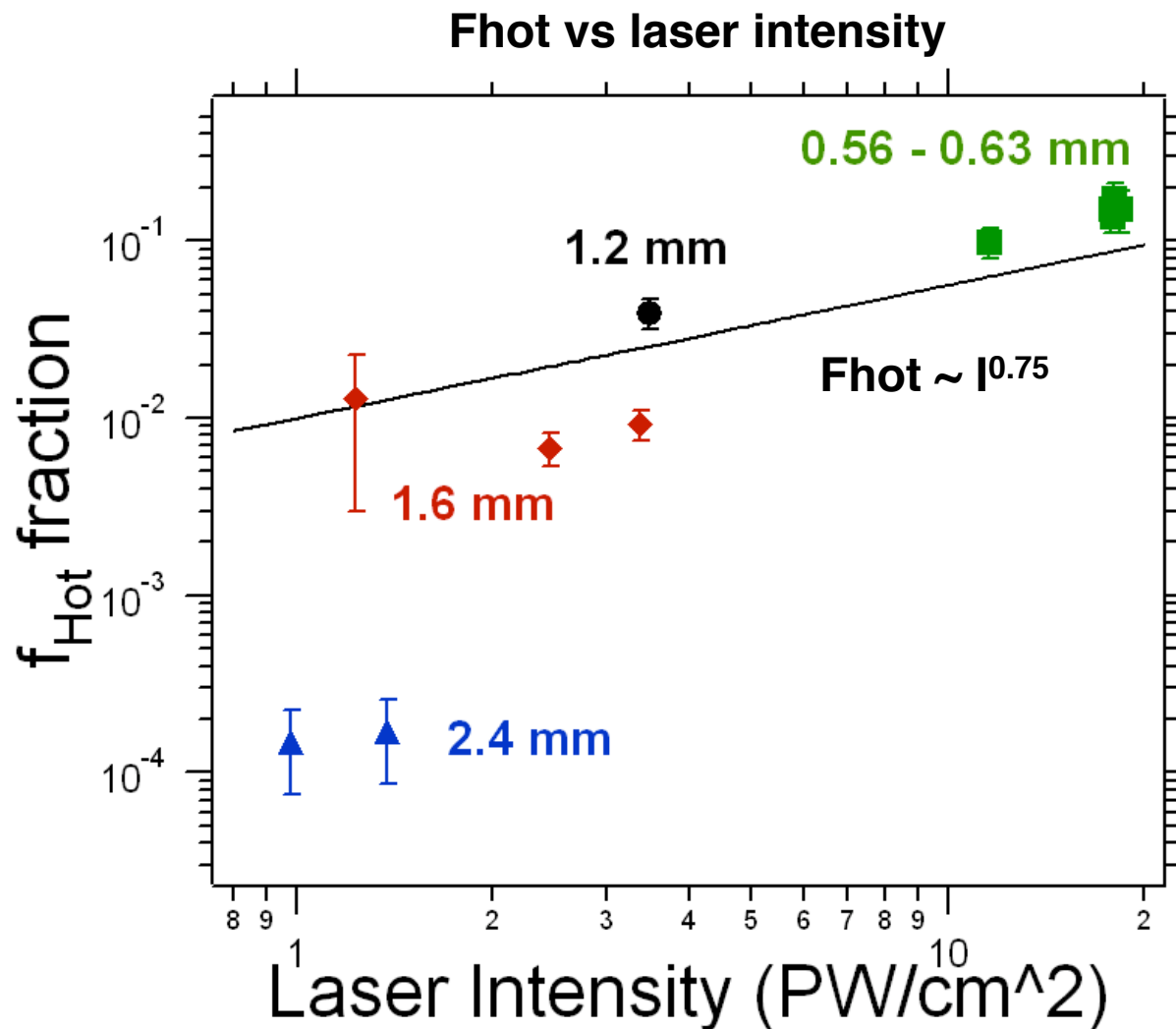


# FFLEX Spectra provide $f_{\text{hot}}$ , $T_{\text{hot}}$ and evidence of Au K $\alpha$ and re-absorption above Au K edge

$$\% f_{\text{hot}} = \frac{\text{Intensity}[\text{keV/keVsr}]}{5e11[\text{keVsr}] E_L[\text{keV}]} \times 100$$



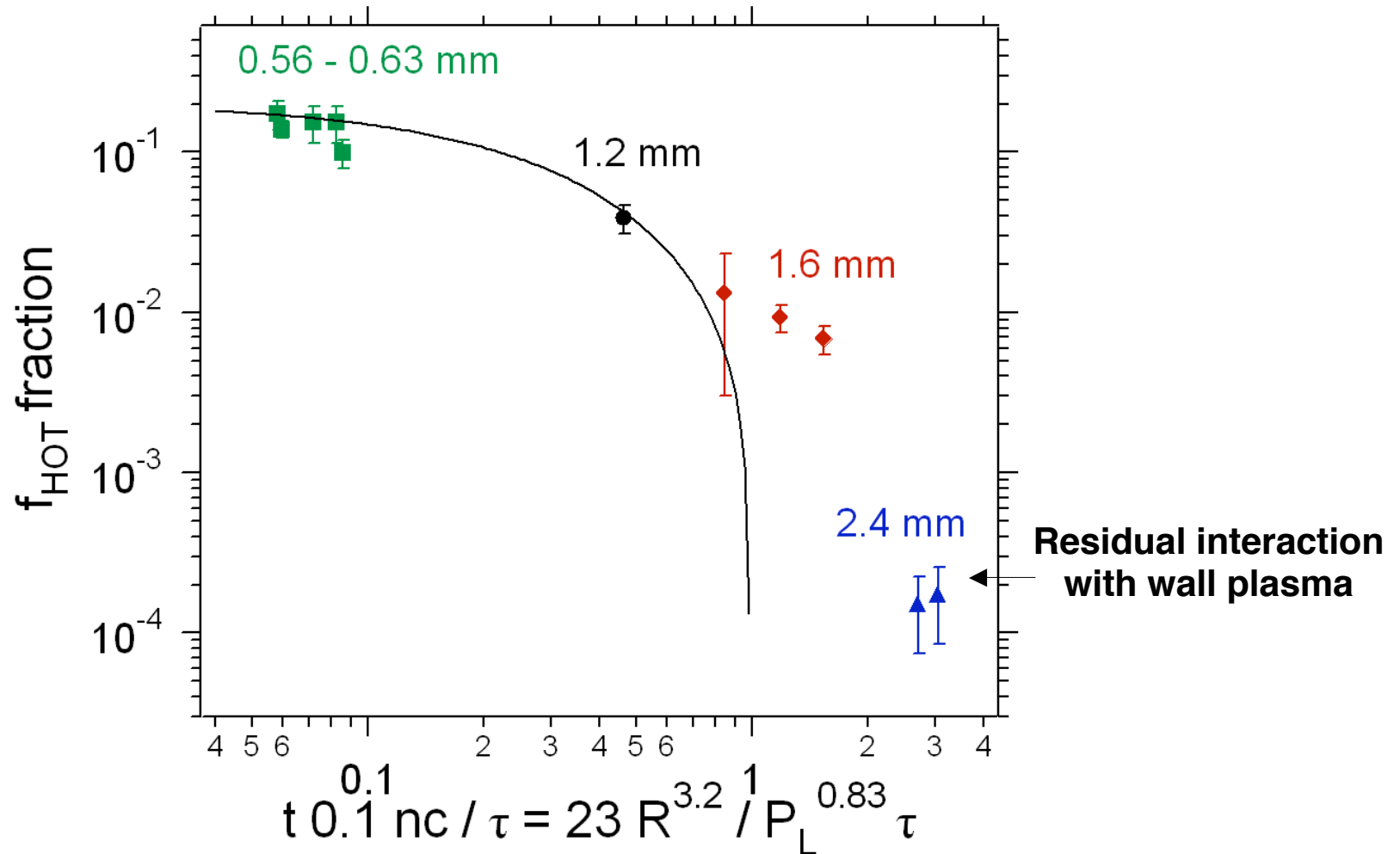
# Fhot scales with intensity



**Secondary trend: Larger hohlraums give less fhot at given intensity**

# Fhot can also be explained by plasma fill model

Fhot vs fraction of pulse for which channel plasma density above  $0.1 n_c$

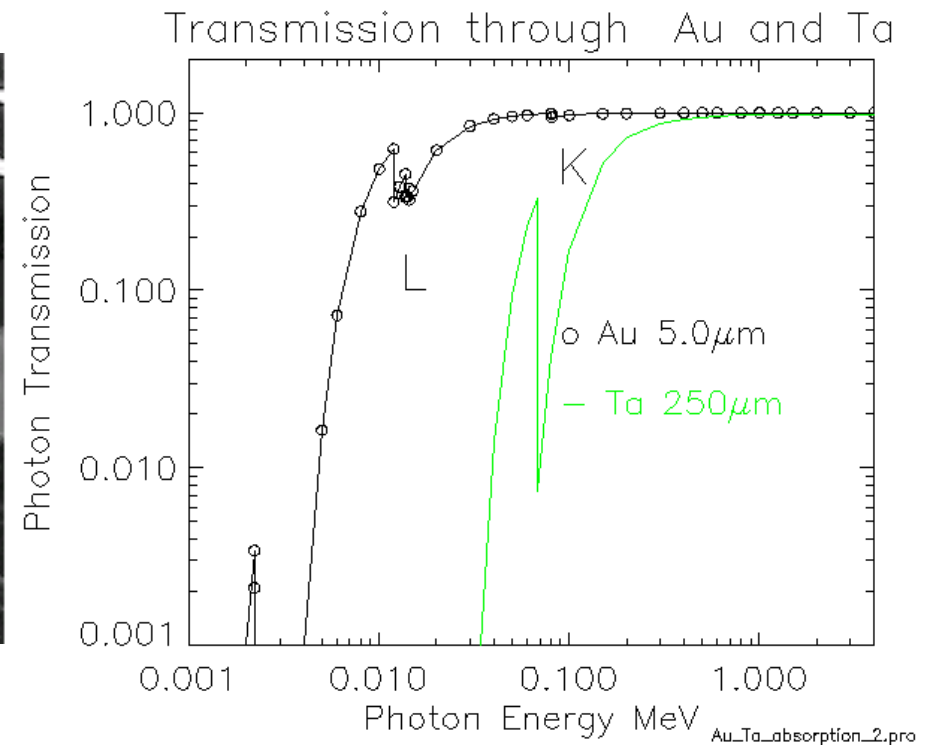
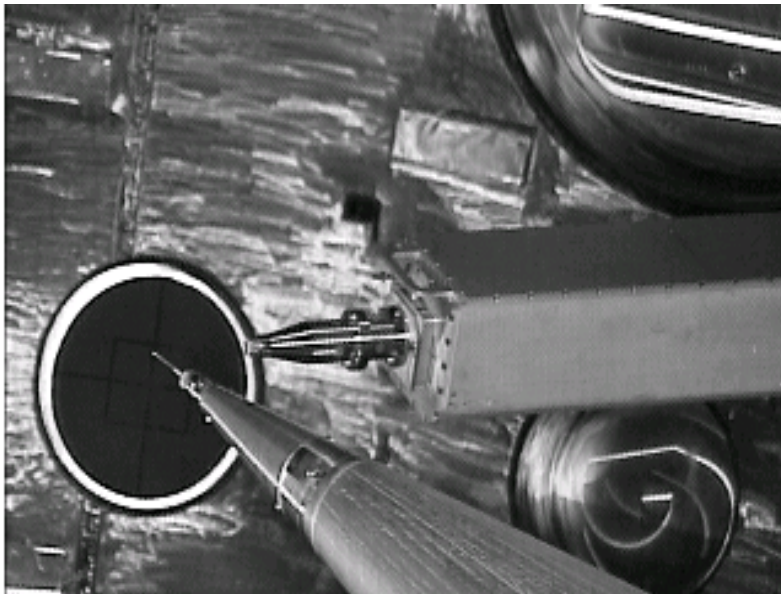


# Hard x-ray imaging designed to provide high contrast 50 – 100 $\mu\text{m}$ 200 ps imaging at $> 9 \text{ keV}$



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- HXRI with 2X snout in NIF vacuum chamber



# FXI/HXRI 10 keV image follows predictions

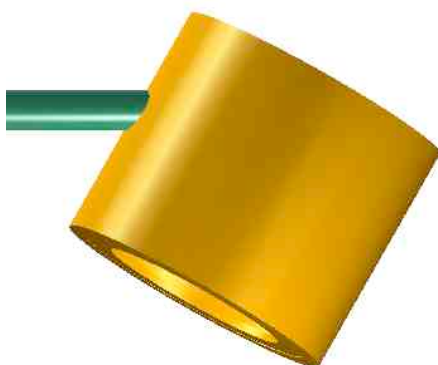


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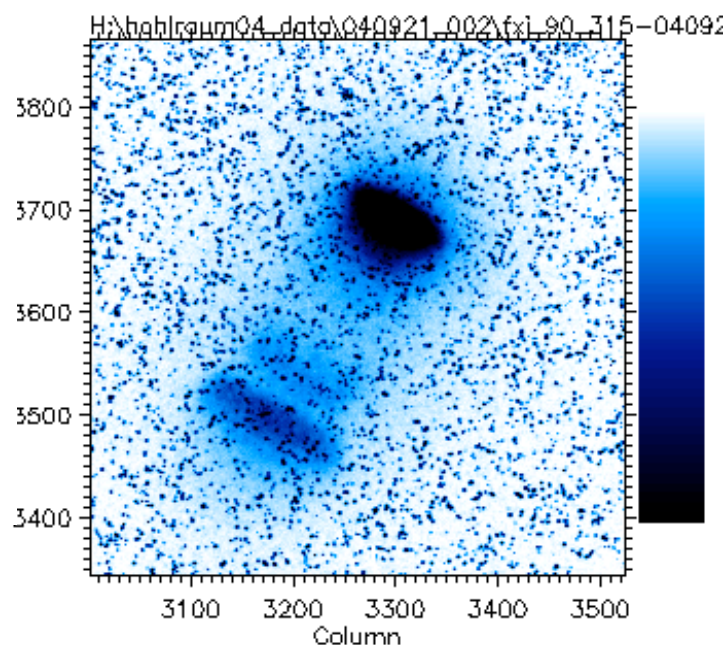
$t = 2 \text{ ns}$  (10 keV imaging)

13 kJ/2 ns

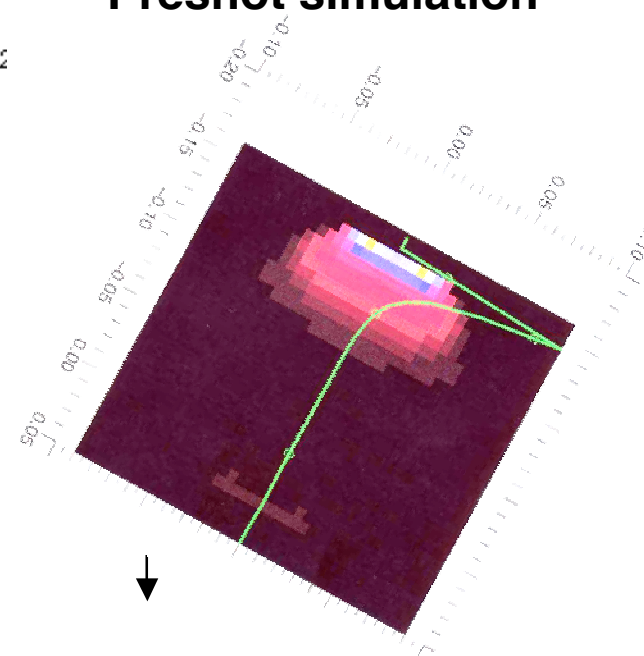
225 eV hohlraum



040921-001 Data

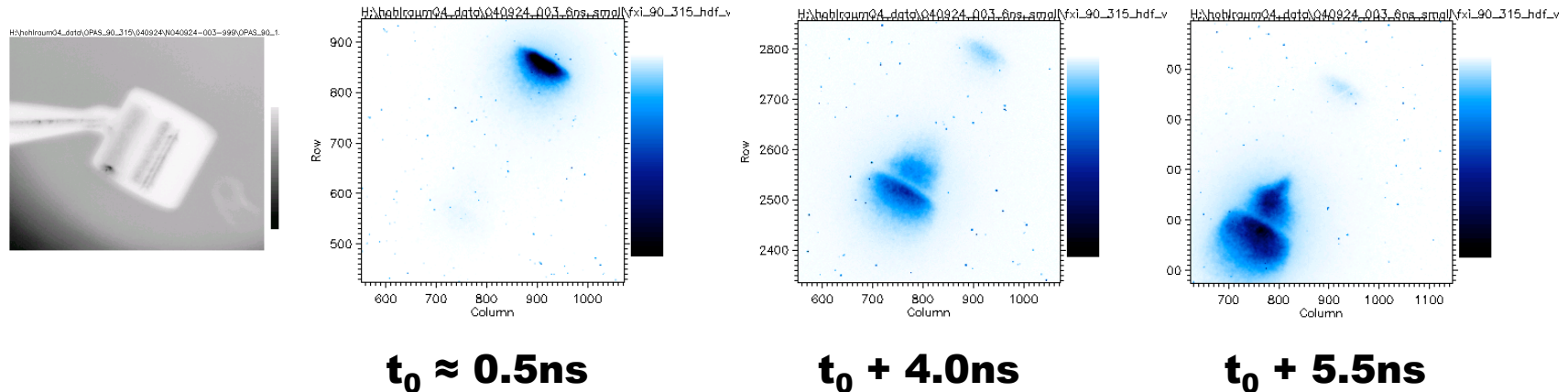


Preshot simulation



# Imaging shows migration of laser absorption and re-emission regime to LEH for longer pulses

## Results from 1.6 mm hohlraum driven by 16 kJ 6 ns pulse



Reversed OPAS

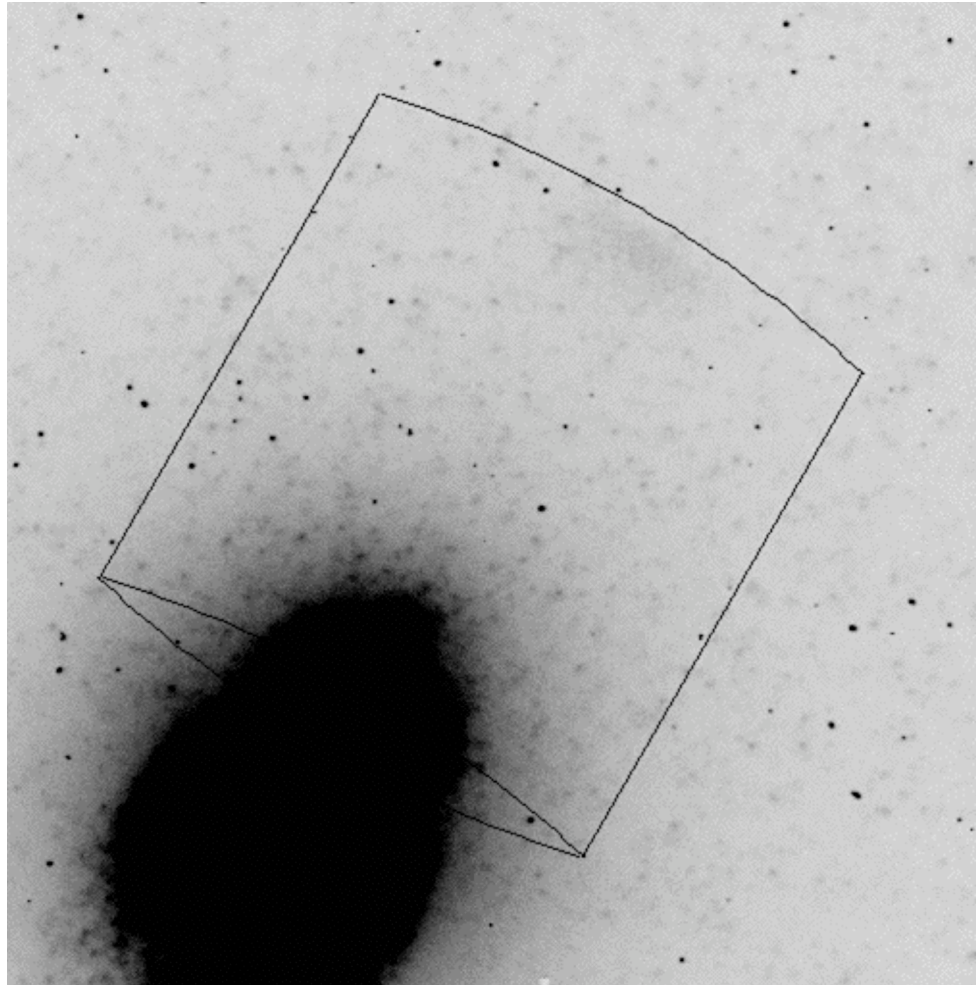


# Animation of plasma migration



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H:\hohlraum04\_data\OPAS\_90\_315\040924\N040924-003-999\OPAS\_90\_1.



**Early on high density plasma filling at LEH, laser energy deposition moves from back wall to LEH. Later in time no laser energy makes it to back wall**

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